

Appl. No. 09/818,193
Amdt. Dated August 23, 2004
Reply to Office Action of June 14, 2004

REMARKS/ARGUMENTS

Claims 1-26 were pending in the present application before the amendment as set forth above. By this Amendment, claims 1, 5-7, 10, 13, 16, 19 and 23-26 are amended, and claims 2-4 and 20-22 are canceled.

The June 14, 2004 Office Action rejected claims 1, 2, 4, 5, 7, 8, 10, 11, 19, 20 and 22 under 35 U.S.C. §102(b) as being anticipated by Li et al, IEEE Electron Device Letters, Vol. 19, 279 (1998), (hereinafter "Li"), and claims 1, 3-5, 7, 8, 10, 11, 19, 21 and 22 under 35 U.S.C. §102(e) as being anticipated by Lai et al, Applied Physics Letters, Vol. 76, 3744 (2000), (hereinafter "Lai"). Furthermore, claims 6, 9, 12, 14-18 and 23-26 were rejected under 35 U.S.C. §103(a) as being unpatentable over Li as applied to claims 1, 2, 4, 5, 7, 8, 10, 11, 19, 20 and 22 above. Additionally, claims 6, 9, 12, 14-18 and 23-26 were rejected under 35 U.S.C. §103(a) as being unpatentable over Lai as applied to claims 1, 3-5, 7, 8, 10, 11, 19, 21 and 22 above. Moreover, claim 13 was under 35 U.S.C. §103(a) as being unpatentable over Lai as applied to 1, 3-12, 14-19 and 21-26 above, and further in view of U.S. Pat. No. 6,297,172 to Kashiwagi.

The Office Action further rejected claim 6 under 35 U.S.C. §112, second paragraph, as being indefinite for failing to particular point out and distinctly claim the subject matter which applicant regards as the invention. Additionally, claims 21-25 were objected under 37 C.F.R. §1.126 as misnumbered.

Applicants appreciate the Examiner's careful review of the application.

In response, as set forth above, claims 1, 5-7, 10, 13, 16, 19 and 23-26 have been amended. In particular, among other things, claims 1 and 19 have respectively been amended to include limitations shown at least in claims 1-26 and specification as originally filed. Claim 6

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has been amended to overcome the Examiner's rejection under 35 U.S.C. §112, second paragraph. Furthermore, claims 22-25 have respectively been amended to correct typos and to renumber the claims as indicated by the Examiner.

The abstract has also been amended, as suggested by the examiner, for better form so that the amended claims, the written description, the abstract and the drawings are consistent with each other.

Additionally, without acquiescing in the propriety of the Examiner's rejections and to facilitate the prosecution of the current application, claims 2-4 and 20-22 have been canceled, which makes the Examiner's rejections under 35 U.S.C. §102 to claims 2-4 and 20-22 moot. Applicants reserve every right in cancelled claims 2-4 and 20-22 to file continuation applications.

Moreover, Applicants respectfully request the Examiner to withdraw Lai as a 35 U.S.C. § 102(e) reference with respect to the present application because the present application claims the benefit of U.S. Provisional Application No. 60/192,009, filed March 24, 2000, which is earlier than the publication date of June 19, 2000 of Lai. Therefore, Lai does not qualify as a 35 U.S.C. § 102(e) reference with respect to the present application. However, even if Lai were a 35 U.S.C. § 102(e) reference, which Applicants do not agree, claims 1, 5-19 and 23-26, as amended, are patentable over the cited references including Lai at least for the reasons more specifically set forth below. To facilitate the prosecution of the present application and for this reason only, Applicants distinguish the present invention from Lai as set forth below even though Applicants believe Lai does not qualify as a 35 U.S.C. § 102(e) reference.

The following remarks herein are considered to be responsive thereto.

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Support for the amendment set forth above can be found in the disclosure as originally filed at least in claims 1-26 and in Figs. 1-8 of the drawings. Thus, no new matter is added. However, the claims are not limited to the disclosed embodiments.

Any amendments to the claims not specifically referred to herein as being included for the purpose of distinguishing the claims from cited references are included for the purpose of clarification, consistence and/or grammatical correction only.

It is now believed that the application is in condition for allowance and such allowance is respectfully requested.

35 U.S.C. §102 Rejections

Claims 1, 2, 4, 5, 7, 8, 10, 11, 19, 20 and 22 were rejected under 35 U.S.C. §102(b) as being anticipated by Li. Furthermore, claims 1, 3-5, 7, 8, 10, 11, 19, 21 and 22 were rejected under 35 U.S.C. §102(e) as being anticipated by Lai. By this amendment, claims 2-4 and 20-22 have been canceled, which makes the Examiner's rejections under 35 U.S.C. §102 to claims 2-4 and 20-22 moot. Applicants respectfully traverse the rejections made by the Examiner at least for the reasons discussed below for claims 1, 5, 7, 8, 10, 11, and 19.

Claims 1, 5, 7, 8, 10 and 11:

As set forth above, among other unique limitations, amended claim 1 recites a method for manufacturing a semiconductor device that requires the steps of "forming a layer of silicon dioxide on a silicon carbide substrate to create a silicon carbide/silicon carbide interface with an interface trap density, and incorporating nitrogen at the silicon dioxide/silicon carbide-interface for reduction in the interface trap density, wherein the silicon carbide substrate comprises *4H-SiC* and is doped with an *n-type dopant*." (Emphasis added.)

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In one embodiment as shown in Fig. 1 of the present application as filed, for example, “[a] semiconductor device 112 has a silicon carbide layer 110 disposed on a silicon carbide substrate 102. The silicon carbide layer 110 consists of two different regions 106 and 108. Region 108, which is located at the SiO/SiC interface 104, is a region of substantial nitrogen concentration. The nitrogen concentration of region 106 is substantially lower than the nitrogen concentration of region 108,” as described in page 5, lines 16-20 of the specification as originally filed. “The silicon carbide substrate 102 is n-type 4H-SiC or 6H-SiC (preferably, 4H-SiC) and may be doped with either a p-type or a[n] n-type dopant,” as described in page 5, lines 16 and 27 of the specification as originally filed.

In contrast, Li discloses a semiconductor fabricated on p-type SiC that demonstrates that “the reliability of oxides grown on *p-type 4H-SiC* can be dramatically improved by NO nitridation. ... Relatively small changes in the flat-band voltage, interface-trap density and leakage current were observed after 5000s in the case of NO nitrided oxides, while shorter stressing shifted these parameters dramatically in the case of N₂ annealed control samples.” Li, Abstract, lines 1-10. (Emphasis added.) Therefore, Li does not disclose or teach a method for manufacturing a semiconductor device that requires the steps of “forming a layer of silicon dioxide on a silicon carbide substrate to create a silicon carbide/silicon carbide interface with an interface trap density, and incorporating nitrogen at the silicon dioxide/silicon carbide-interface for reduction in the interface trap density, wherein the silicon carbide substrate comprises *4H-SiC* and is doped with an *n-type dopant*.” *In short, Li relates to a semiconductor fabricated on p-type 4H-SiC, which is different from a semiconductor fabricated on n-type 4H-SiC the present invention utilizes.*

Furthermore, Lai investigates “effects of N₂O nitridation and subsequent annealing in different conditions on thermallyoxidized *n-type 6H-silicon carbide (SiC)* metal-oxide-semiconductor (MOS) interface properties” which demonstrates that “nitridation deteriorates the interface quality, while subsequent O₂ annealing (especially in dry O₂) can repair the interface.

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The reliability of the O₂-annealed nitrided oxides is slightly reduced due to a decrease of nitrogen content during annealing.” Lai, pages 3744 and 3745. (Emphasis added.) Therefore, Lai does not disclose or teach a method for manufacturing a semiconductor device that requires the steps of “forming a layer of silicon dioxide on a silicon carbide substrate to create a silicon carbide/silicon carbide interface with an interface trap density, ... wherein the silicon carbide substrate comprises *4H-SiC* and is doped with an *n-type dopant*.” *Again, in sum, Lai relates to an n-type 6H-SiC, which is different from an n-type 4H-SiC the present invention utilizes.*

Therefore, neither Li nor Lai, taken alone or in combination, suggest or teach a method for manufacturing a semiconductor device that requires the steps of “forming a layer of silicon dioxide on a silicon carbide substrate to create a silicon carbide/silicon carbide interface with an interface trap density, and incorporating nitrogen at the silicon dioxide/silicon carbide-interface for reduction in the interface trap density, wherein the silicon carbide substrate comprises *4H-SiC* and is doped with an *n-type dopant*.”

For at least the foregoing reasons, independent claim 1, as amended, is patentable under 35 U.S.C. § 102(b) and 35 U.S.C. § 102(e) over the cited references.

Accordingly, claims 8 and 11, and amended claims 5, 7 and 10, which depend from now allowable amended claim 1, are patentable at least for this reason.

Claims 19:

As set forth above, among other unique limitations, amended claim 19 recites a semiconductor device with reduction in interface trap density in a silicon carbide/silicon carbide interface comprising “a silicon carbide substrate, a layer of silicon dioxide disposed on the silicon carbide substrate to create a silicon dioxide/silicon carbide interface with an interface trap density, and a region of substantial nitrogen concentration at the silicon dioxide/silicon carbide

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interface for reduction in the interface trap density, wherein the silicon carbide substrate comprises *4H-SiC* and is doped with an *n-type dopant*." (Emphasis added.)

Claim 19, as amended, is a device claim corresponding to amended method claim 1. Incorporating the reasons as set forth above why amended claim 1 is patentable under 35 U.S.C. § 102(b) and 35 U.S.C. § 102(e) over the cited references herein, amended claim 19 is patentable over Li and Lai at least for the same reasons.

35 U.S.C. §103 Rejections

Claims 6, 9, 12, 14-18 and 23-26 were rejected under 35 U.S.C. §103(a) as being unpatentable over Li as applied to claims 1, 2, 4, 5, 7, 8, 10, 11, 19, 20 and 22 above. Additionally, claims 6, 9, 12, 14-18 and 23-26 were rejected under 35 U.S.C. §103(a) as being unpatentable over Lai as applied to claims 1, 3-5, 7, 8, 10, 11, 19, 21 and 22 above. Moreover, claim 13 was under 35 U.S.C. §103(a) as being unpatentable over Lai as applied to 1, 3-12, 14-19 and 21-26 above, and further in view of U.S. Pat. No. 6,297,172 to Kashiwagi. Applicants respectfully traverse the rejections made by the Examiner at least for the reasons discussed below.

Claims 6, 9 and 12-18:

Claims 9, 12, 14, 15 and 17, and amended claims 6, 13 and 16 depend from now allowable amended claim 1 and thus are patentable at least for this reason.

Claims 23-26:

Amended claims 23-26 depend from now allowable amended claim 19 and thus are patentable at least for this reason.

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CONCLUSION

Applicants respectfully submit that the foregoing Amendment and Response place this application in condition for allowance. If the Examiner believes that there are any issues that can be resolved by a telephone conference, or that there are any informalities that can be corrected by an Examiner's amendment, please call the undersigned at 404.495.3678.

Respectfully submitted,
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